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Tailings dams stability analysis using numerical modelling of geotechnical and geophysical data

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Methods for monitoring seepage and detecting internal erosion are essential for the safety evaluation of embankment dams. Internal erosion is one of the major reasons for embankment dam failures, and there are thousands of large tailings dams and waste-rock dumps in the world that may pe considered as hotspots for environmental impact. In this research the geophysical survey works were performed on Cetatuia 2 tailings dam. Electrical resistivity imaging (ERI) method was able to detect spatially anomalous zones inside the embankment dam. These anomalies are the results of internal erosion phenomena which may progressing inside the dam and is difficult to detect by conventional methods. Data aquired by geophysical survey together with their interpretations were used in the numerical model for slope stability assessment. The final results show us the structural weakness induced by the presence of internal erosion elements especially for seismic loading case. This research methodology may be also available for tailings dam monitoring purposes.

Electrical Rezistivity Imaging (ERI) was performed on Cetatuia 2 dam at the Uranium Milling Plant Feldioara, in order to map areas with lateral and vertical changes in resistivity. The electrodes are connected to an automated computer operated switch box that selects the 4 electrodes to be used. A computer controls the switch box and the measuring device, and runs a program that selects the electrodes, makes the measurement, and stores the measurement. For inversion processing procedures was used Res2Din software. The measured resistivity were plotted by the pseudo section contouring method.

There are five resistivity pseudosections obtained from the Cetatuia 2 tailings dam during the october 2007 measurements. Four transversal profiles trans1 to trans4 are perpendicular to the berms and the longitudinal one long1 is placed along dam's crest. The high resistivities near the berms surfaces corresponds to unsaturated fill materials and the low resistivities near the crest correspond to water saturated material. The resistivities values greater then 80 ohm.m may be explained by some error obtained for that inversion model. Profiles trans3 and trans4 were measured on perpendicular directions to berm alignment and show two distinct zones.

The upward low resistivities zone correspond to water saturated materials especially from the compacted clay dam's core and the downward high resistivities zone belongs to unsaturated fill materials. The boundary between high and low resistivity at the depth of about 5 to 7 meters shows the groundwater level. The continuation of the high resistivity zones towards the end of the profile trans3, which is different from other profiles is probably due to the presence of dry coarse materials in shallow depth correspondingly to sandy clay. The sand fractions from the clay matrix may be affected by internal erosional phenomena, due to seepage currents that overpassed the material critical gradient. In this case the relative high resistivities values were considered as a presumptive erosional pattern. This profile was considered for the slope stability finite element modelling.

The profile long1 which is placed along dam's crest is the longest profiles and extends up to nearly 420 m. The boundary between high and low resistivity at the depth of about 4 to 8 meters shows the groundwater across the dam core. The central part of the profile (about meter 200) shows the same relative high resistivities that occurred on transversal profile trans3.

Resistivity data was used for building the 3D electrical resistivity model. The water saturated materials have locations very close to dam's crest (resistivity values usually lower then 10 ohm.m) and on both dam's arms. The groundwater levels were confirmed by the piezometric measurements. Electrical Rezistivity Imaging method had the possibility to show the most important disturbant elements that in certain conditions may weak the dam's state of safety.

This study considered the SSR (Shear Strength Reduction) technique for slope stability numerical modelling. In

the SSR finite element technique, elasto-plastic strength is assumed for dam's materials and shear strengths are progressively reduced until collapse occurs.

Numerical modelling was performed on the most critical profile choosed through analysis of geophysical and geotechnical informational volume achieved by insitu or in laboratory tests. Finite element analysis were considered in two situations: first, before geophysical investigations and second considering the whole informational of data achieved. Both situations were analysed in static and pseudo-static conditions.

The factor of safety before geophysical investigations is high enough to describe a stable state of stability even for the seismic load.

The total displacement distributions were modified by the presence of internal erosional element giving a high state of instability, especially for the pseudo-static case. These analysis using the finite element method prove the importance of structural disturbance elements that may occure inside the dam body produced by internal erosional processes.